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(56) Documents Cited

GB 2261804 A EP 0539907 A2 WO 95/10106 A1  
WO 95/04435 A1 US5348477 A US 4636866 A

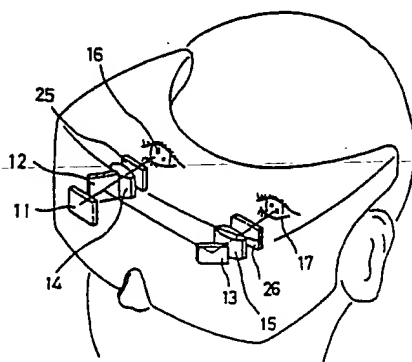
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(54) Head-mounted display including single image display device

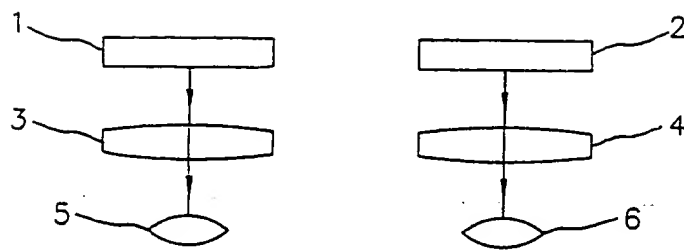
(57) A head-mounted display apparatus comprises a single image display device 11, a beam splitter 12 for partially transmitting and partially reflecting light from the image display device, a reflection mirror 13, and first and second magnifying lenses 14 and 15 respectively disposed between the beam splitter and the right eye 16 and between the reflection mirror and the left eye 17 thereby enabling the observer to see enlarged virtual image formed at a certain distance from the eyes. The head-mounted display apparatus can also provide a stereoscopic vision by displaying images on the image display device on the basis of the principle of binocular parallax using shutter glasses 25 and 26. In a further embodiment the apparatus includes concave mirrors and additional half mirrors (figs 6 and 7).

FIG. 5

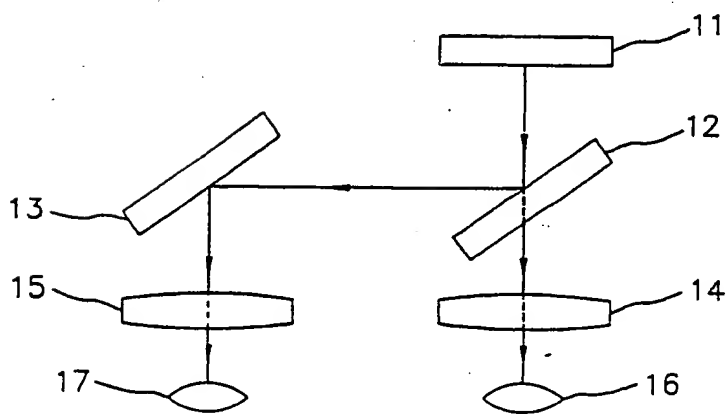


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*FIG. 1*  
(PRIOR ART)



*FIG. 2*



*FIG. 3*

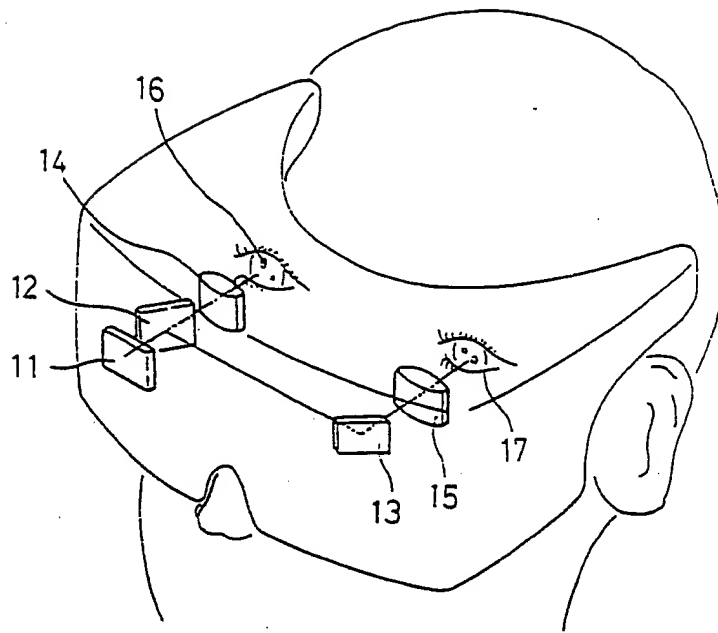


FIG. 4

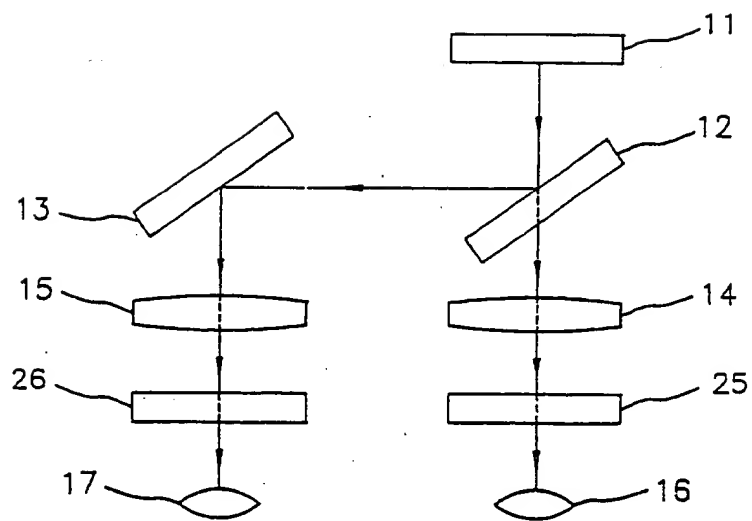


FIG. 5

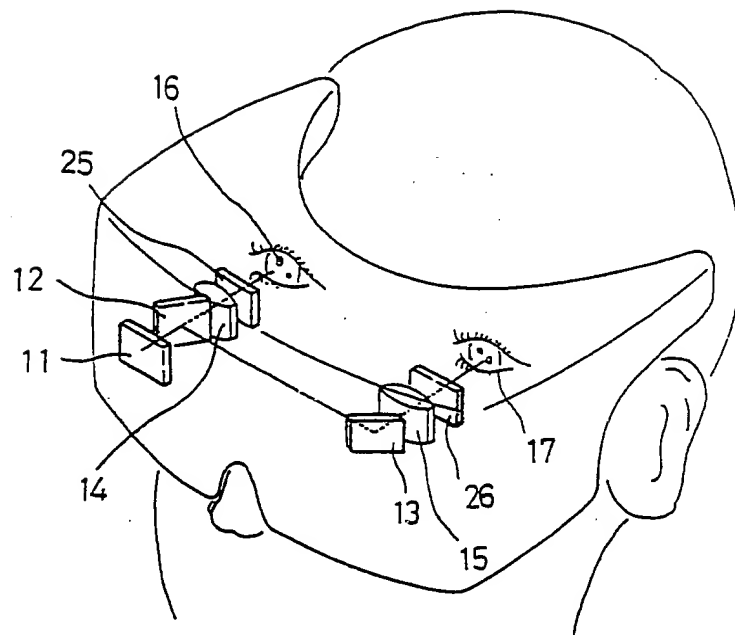


FIG. 6

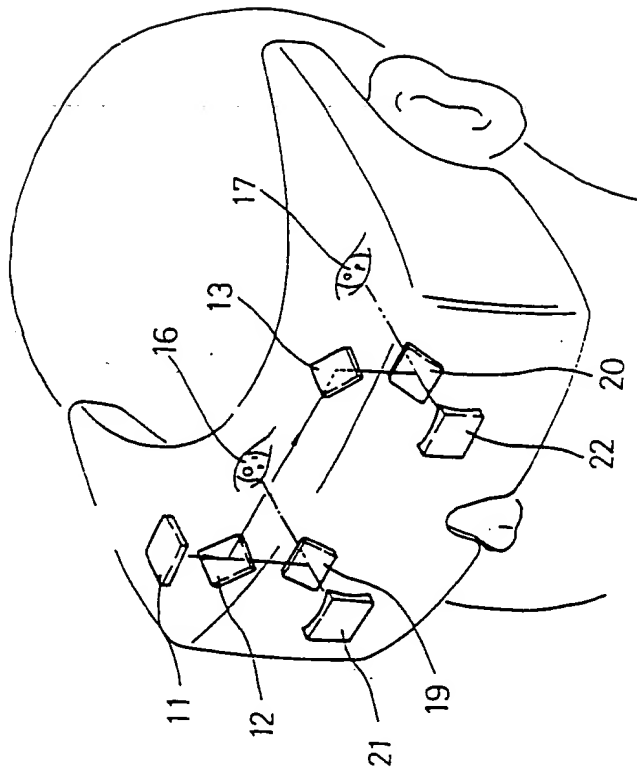
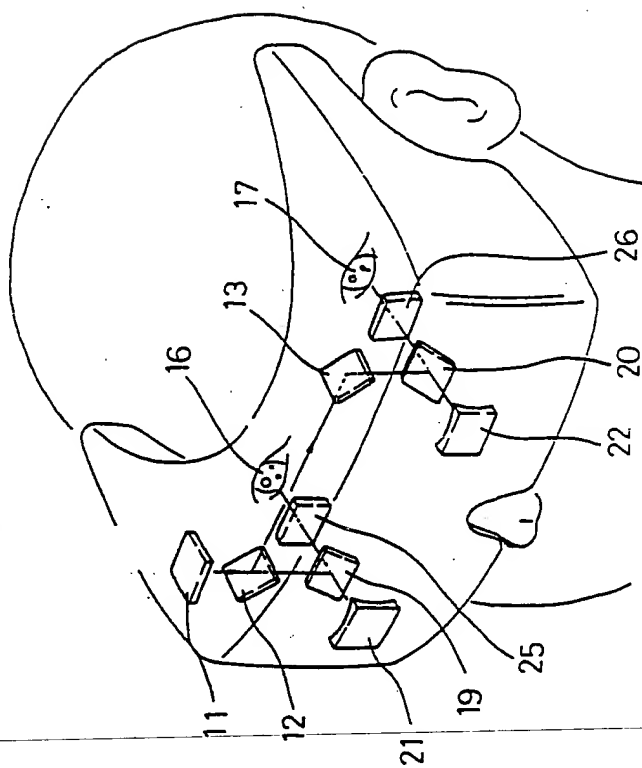


FIG. 7



HEAD-MOUNTED DISPLAY APPARATUS  
WITH A SINGLE IMAGE DISPLAY DEVICE

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The present invention relates to a head-mounted display apparatus; and, more particularly, to a head-mounted display apparatus incorporating therein a single image display device.

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There is shown in Fig. 1 a schematic diagram of a conventional head-mounted display apparatus comprising a pair of image display devices 1, 2, e.g., liquid crystal displays, and a pair of magnifying lenses 3, 4.

15

The image display devices 1, 2, disposed in front of left and right eyes 5, 6 of an observer, respectively, are connected to a video signal source (not shown) and display images on the basis of video signals therefrom.

20

The magnifying lenses 3, 4 are positioned between the image display devices 1, 2 and the left and the right eyes 5, 6, respectively, thereby enabling the observer to see enlarged virtual images formed at a certain distance from the eyes 5, 6.

25

However, as a result of the presence of two image display devices, such a conventional head-mounted display apparatus is



fairly heavy, making it burdensome on the observer's head. In addition, there exists a complicated circuit for transmitting the video signals to the individual image display device.

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It is, therefore, a primary object of the invention to provide a head-mounted display apparatus having a reduced weight and a simplified circuit by incorporating therein a  
10 single image display device.

In accordance with an aspect of the present invention, there is provided a head-mounted display apparatus comprising: an image display device for displaying images; means for splitting light from the image display device into two light  
15 beams, one of the light beams being led to one eye of an observer; a reflection mirror for reflecting the other light beam split by the light splitting means to the other eye of the observer; and a first and a second magnifying lenses disposed between the beam splitter and one eye of the observer  
20 and between the reflection mirror and the other eye, respectively.

In accordance with another aspect of the present invention, there is provided a head-mounted display apparatus comprising: an image display device for displaying images;  
25 means for splitting light from the image display device into two light beams; a reflection mirror for reflecting one of the

light beams split by the light splitting means; a first and a second half mirrors for reflecting the other light beam split by the splitting means and the light beam reflected by the reflection mirror, respectively; and a first and a second concave reflection mirrors for reflecting the light beams from the first and the second half mirrors to one eye and the other eye of an observer, respectively.

10

The above and other objects and features of the present invention will become apparent from the following description of preferred embodiments taken in conjunction with the accompanying drawings, in which:

15

Fig. 1 shows a schematic diagram of a conventional head-mounted display apparatus;

20

Figs. 2 and 3 illustrate a schematic diagram and a schematic perspective view of a head-mounted display apparatus in accordance with a preferred embodiment of the present invention, respectively;

Figs. 4 and 5 illustrate a schematic diagram and a schematic perspective view of a head-mounted display apparatus in accordance with the third preferred embodiment of the present invention, respectively;

25

Fig. 6 sets forth a schematic perspective view of a head-mounted display apparatus in accordance with another preferred

embodiment of the present invention; and

Fig. 7 sets forth a schematic perspective view of a head-mounted display apparatus in accordance with the fourth preferred embodiment of the present invention.

5

There are shown in Figs. 2 to 7 various views of the head-mounted display apparatus of the present invention, wherein like reference numerals represent same components.

There are respectively shown in Figs. 2 and 3 a schematic diagram and a schematic perspective view of a head-mounted display apparatus in accordance with a preferred embodiment of the present invention. The head-mounted display apparatus of the first preferred embodiment comprises an image display device 11, e.g., a liquid crystal display or cathode ray tube, a beam splitter 12 for partially transmitting and partially reflecting light from the image display device 11, a reflection mirror 13, and a first and a second magnifying lenses 14, 15.

The image display device 11, disposed in front of, e.g., a right eye 16 of an observer, is connected to a video signal source (not shown) such as a personal computer, a video cassette recorder, a laser disc player etc., and displays images on the basis of video signals therefrom.

The beam splitter 12, disposed between the image display

device 11 and the right eye 16, partially transmits and partially reflects the light from the image display device 11 in proportion of 1 : 1, thereby splitting it into two light beams. One of the light beams is led through the beam splitter 12 to the right eye 16 and the other is led to the reflection mirror 13 disposed in front of a left eye 17 of the observer, and is, then, totally reflected by the reflection mirror 13 to the left eye 17.

The first and the second magnifying lenses 14, 15 are respectively disposed between the beam splitter 12 and the right eye 16 and between the reflection mirror 13 and the left eye 17, thereby enabling the observer to see enlarged virtual image formed at a certain distance from the eyes 16, 17.

The head-mounted display apparatus of the present invention can also provide a stereoscopic vision by displaying images on the image display device on the basis of the principle of binocular parallax.

There are shown in Figs. 4 and 5 a schematic diagram and a schematic perspective view of a head-mounted display apparatus in accordance with another preferred embodiment of the present invention, respectively, which provides a stereoscopic vision. The head-mounted display apparatus of the second preferred embodiment, as compared with the first, further comprises a first and a second shutter glasses 25, 26 disposed between the first magnifying lens 14 and the right eye 16 and between the second magnifying lens 15 and the left

eye 17, wherein the image display device 11 alternately displays right-eye and left-eye images photographed from two different directions or angles.

5 The first and the second shutter glasses 25, 26, synchronized with the right-eye and the left-eye images displayed on the image display device 11, become alternately clear and cloudy so that the observer is able to see three dimensional images. The first and the second shutter glasses 25, 26 are made of a liquid crystal material, as disclosed in  
10 detail in U.S. Pat. Nos. 4,907,860 and 5,539,423, which are incorporated herein by reference.

Furthermore, there is shown in Fig. 6 a schematic perspective view of a head-mounted display apparatus in accordance with further another preferred embodiment of the  
15 present invention. The head-mounted display apparatus of the third preferred embodiment comprises an image display device 11, a beam splitter 12 for partially transmitting and partially reflecting the light from the image display device 11, a reflection mirror 13, a first and a second half mirrors  
20 19, 20 and a first and a second concave reflection mirrors 21, 22.

The image display device 11 is disposed on the frontal and upper side of the right eye 16 of the observer, and the beam splitter 12 is positioned thereunder. Furthermore, the  
25 reflection mirror 13 is disposed, on the same level as that of the beam splitter, on the left side of the observer.

The first and the second half mirrors 19, 20 are positioned under the beam splitter 12 and the reflection mirror 13, corresponding to the right and the left eyes 16, 17, respectively. The first and the second concave reflection mirrors 21, 22 are disposed on the reflection side of the half mirrors 19, 20.

The beam splitter 12 partially transmits and partially reflects the light from the image display device 11 in proportion of 1 : 1. The first half mirror 19 partially reflects the light from the beam splitter 12 to the concave reflection mirror 21, and the light from the first concave reflection mirror 21 is transmitted through the half mirror 19 to the right eye 16.

On the other hand, the reflection mirror 13 totally reflects the light reflected by the beam splitter 12 to the second half mirror 20. The second half mirror 20 partially reflects the light from the reflection mirror 13, and the light from the second concave reflection mirror 22 is, then, transmitted through the second half mirror 20 to the left eye 17.

Furthermore, there is shown in Fig. 7 a schematic diagram of a head-mounted display apparatus in accordance with the fourth preferred embodiment of the present invention, which provides a stereoscopic vision. The head-mounted display apparatus of the fourth preferred embodiment, as compared to the third, further comprises the first and the second shutter

glasses 25, 26 disposed between the first half mirror 19 and the right eye 16 and between the second half mirror 20 and the left eye 17, and the image display device 11 alternately displays right-eye and left-eye images photographed from two  
5 different directions or angles.

The first and the second shutter glasses 25, 26, synchronized with the right-eye and the left-eye images displayed on the image display device 11, become alternately clear and cloudy so that the observer is able to see three  
10 dimensional images.

In such head-mounted display apparatuses of the present invention, since only one image display device is required, the weight thereof is decreased, thereby reducing the burden on the observer's head. In addition, the circuit for  
15 transmitting the video signals to the image display device is much more simpler.

Although the invention has been shown and described with respect to the preferred embodiments, it will be understood by those skilled in the art that various changes and  
20 modifications may be made without departing from the

scope of the invention as defined in the following claims.

What is claimed is:

1. A head-mounted display apparatus comprising:

an image display device for displaying images;

5 means for splitting light from the image display device into two light beams, one of the light beams being led to one eye of an observer;

a reflection mirror for reflecting the other light beam split by the light splitting means to the other eye of the observer; and

10 a first and a second magnifying lenses disposed between the beam splitter and one eye of the observer and between the reflection mirror and the other eye of the observer, respectively.

15 2. The apparatus of claim 1, wherein the light splitting means is a beam splitter partially transmitting and partially reflecting the light from the image display device.

20 3. The apparatus of claim 1, further comprising a first and a second shutter glasses disposed between the first magnifying lens and one eye of the observer and between the second magnifying lens and the other eye of the observer, respectively, wherein the image display device alternately

25 displays right-eye and left-eye images photographed from different angles, and the first and the second shutter



glasses, synchronized with the right-eye and the left-eye images displayed on the image display device, become alternately clear and cloudy so that the observer is able to see three dimensional images.

5

4. The apparatus of claim 3, wherein the first and the second shutter glasses are made of a liquid crystal material.

5. A head-mounted display apparatus comprising:  
10 an image display device for displaying images;  
means for splitting light from the image display device into two light beams;  
a reflection mirror for reflecting one of the light beams split by the light splitting means;  
15 a first and a second half mirrors for reflecting the other light beam split by the splitting means and the light beam reflected by the reflection mirror, respectively; and  
a first and a second concave reflection mirrors for reflecting the light beams from the first and the second half  
20 mirrors to one eye and the other eye of an observer, respectively.

6. The apparatus of claim 5, wherein the light splitting means is a beam splitter partially transmitting and partially  
25 reflecting the light from the image display device.

7. The apparatus of claim 5, further comprising a first and  
a second shutter glasses disposed between the first half  
mirror and one eye of the observer and between the second half  
mirror and the other eye of the observer, respectively,  
5 wherein the image display device alternately displays right-  
eye and left-eye images photographed from different angles,  
and the first and the second shutter glasses, synchronized  
with the right-eye and the left-eye images displayed on the  
image display device, become alternately clear and cloudy so  
10 that the observer is able to see three dimensional images.

8. The apparatus of claim 7, wherein the first and the  
second shutter glasses are made of a liquid crystal material.

15 9. A head-mounted display apparatus constructed and arranged  
substantially as herein described with reference to or as  
shown in Figures 3-7 of the accompanying drawings.



## Office

Application No: GB 9703963.0  
Claims searched: 1-9

Examiner: John Coules  
Date of search: 28 April 1997

### Patents Act 1977 Search Report under Section 17

#### Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4F FDD; G2J JVAX,JAS

Int Cl (Ed.6): H04N 13/00,13/04,15/00; G02B 27/00,27/01,27/10,27/22

Other:

#### Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X:Y	GB 2261804 A (EVANS & SUTHERLAND) see claims, fig 2, and page 8 line 34 to page 9 line 6	1,2,5,6: 3,4,7,8
A	EP 0539907 A2 (K K SEGA ENTERPRISES)	
X:Y	WO 95/10106 A1 (VIRTUAL VISION) see fig 13	1,2: 3,4
X	WO 95/04435 A1 (HOLAKOVSKY) see page 2 lines 3-15	1,2
X:Y	US 5348477 (CAE) see fig 2	1,2,5,6: 3,4,7,8
Y	US 4636866 (SEIKO EPSON) see fig 7 and column 5 lines 15-23	3,4,7,8

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X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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